Estimating large scale dynamic mountain glacier states with numerical modelling and data assimilation

Introducing COMBINE

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Introduction

- Started my PhD in September 2021,

  in the PROVIDE Project www.provide-h2020.eu

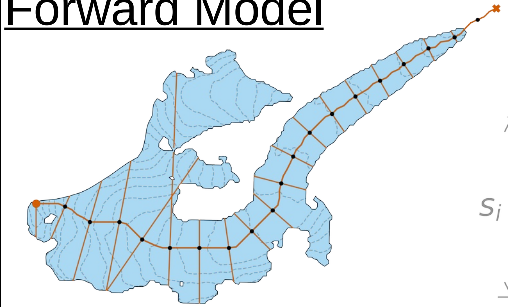
  as part of the Open Global Glacier Model (OGGM) Team

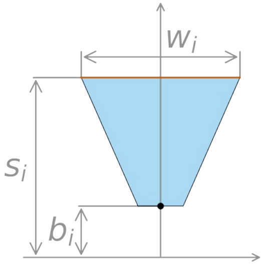
- **<u>Goal:</u>** Project mountain glacier contribution to freshwater availability for different scenarios.

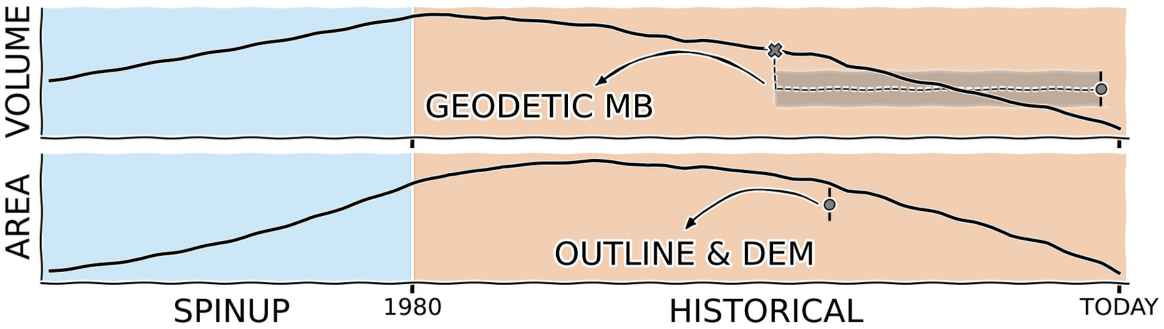
- **<u>Problems</u>** <u>(on a global scale)</u>**<u>:</u>**
  - Better projections require a data informed and consistent initial state!
  - Until recently one outline (with DEM) available ⟹ equilibrium assumption
  - But more data is getting available (geodetic mass-balance, surface ice velocity)
  - How to **incorporate** this **new data** to **initialize a transient glacier model**?

COMBINE
COst Minimization Bed INvErsion model = OGGM Open Global Glacier Model meets PyTorch

Forward Model





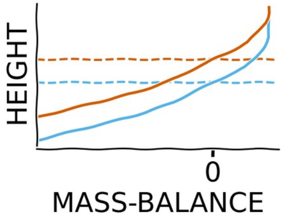


Cost Function

$$\mathcal{J}(\zeta) = \lambda_{dV} \frac{1}{\sigma_{dV}^2} (dV_m(\zeta) - dV_o)^2 + \lambda_s \frac{1}{n\sigma_s^2} \sum_{i=1}^{n} (s_{m,i}(\zeta) - s_{o,i})^2 + \frac{\lambda_b}{n} \sum_{i=1}^{n} \left(\frac{\partial b}{\partial x} \right)^2$$

Update ζ using Automatic Differentiation of PyTorch

Glacier bed heights $\mathbf{b}_i$ & MB-SPINUP height shift



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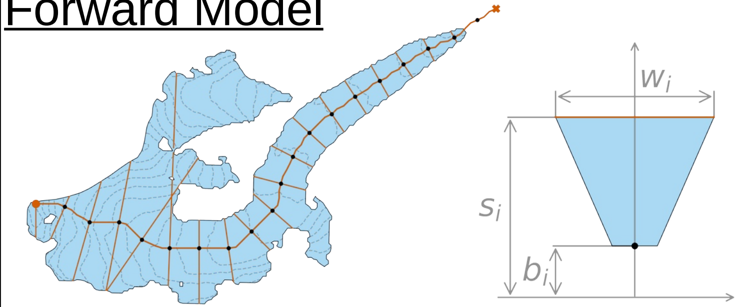

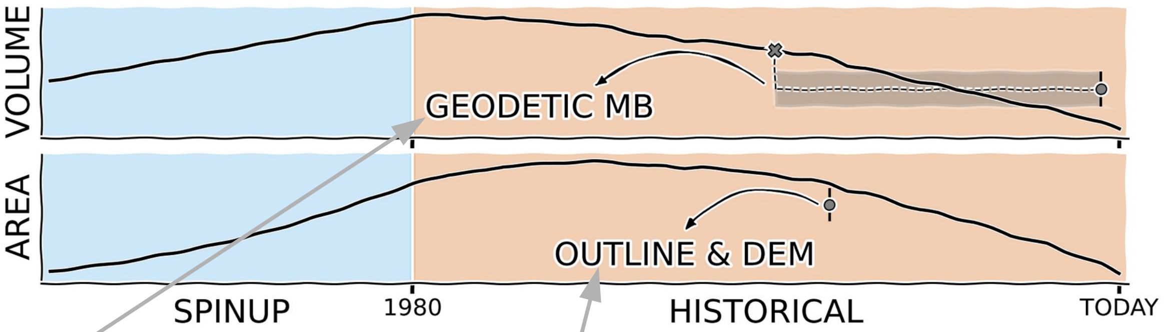

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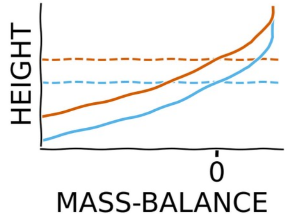

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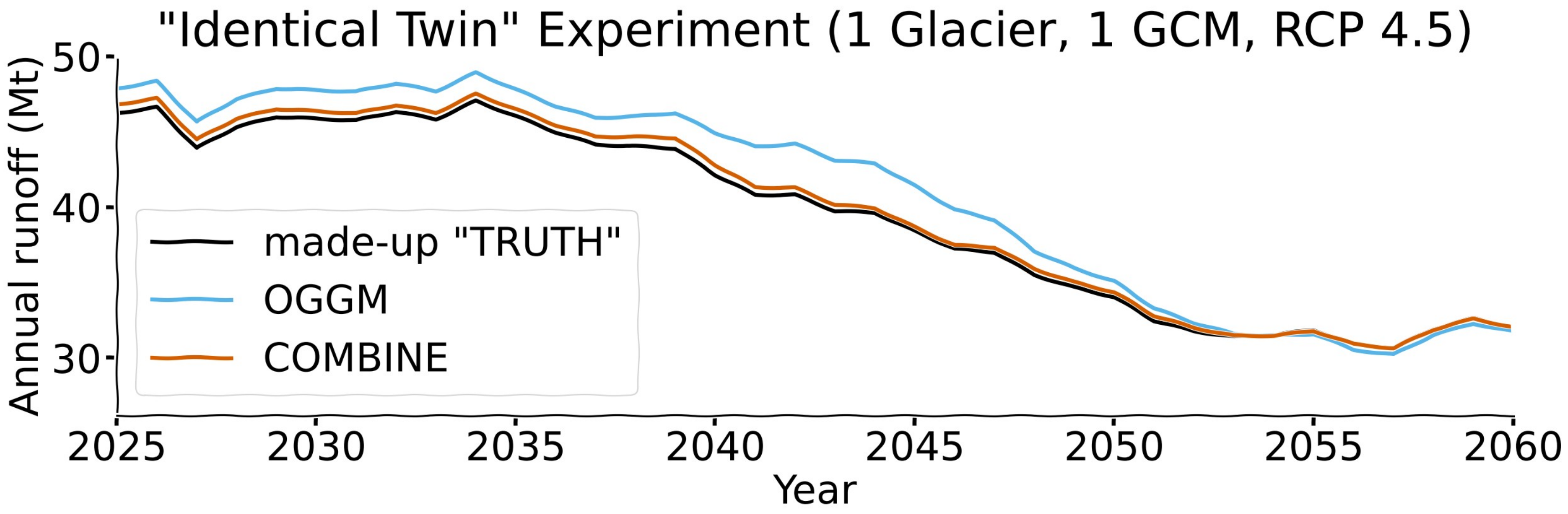
Patrick Schmitt, Session CR 2.9, EGU22-5113

(preliminary, unpublished) Results & Outlook



<u>Upcoming Challenges</u>

- Regularization methods
- Deal with model uncertainty
- Calibrate free model parameters
- Use surface ice velocity observations
- Include MB-model as control

Thank you for your attention!

Any questions or want to get in touch:

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GitHub: github.com/OGGM/COMBINE

This presentation participates in OSPP

EGU

Outstanding Student & PhD candidate Presentation contest

References:

- Horizon 2020 Project PROVIDE www.provide-h2020.eu
- Open Global Glacier Model OGGM oggm.org
- Paszke, A., and Coauthors, 2019: Pytorch: An imperative style, high-performance deep learning library. Advances in Neural Information Processing Systems 32, Curran Associates, http://papers.neurips.cc/paper/9015-pytorch-an-imperative-style-high-performance-deep-learning-library.pdf